Smaller Satellites, Bigger Return

Mission Success at the Space Flight Laboratory (SFL)

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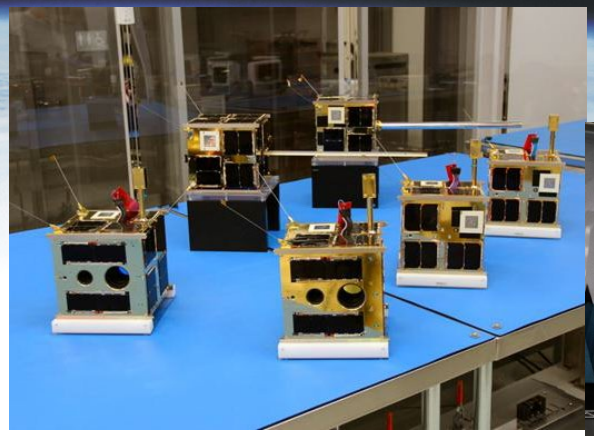
Overview

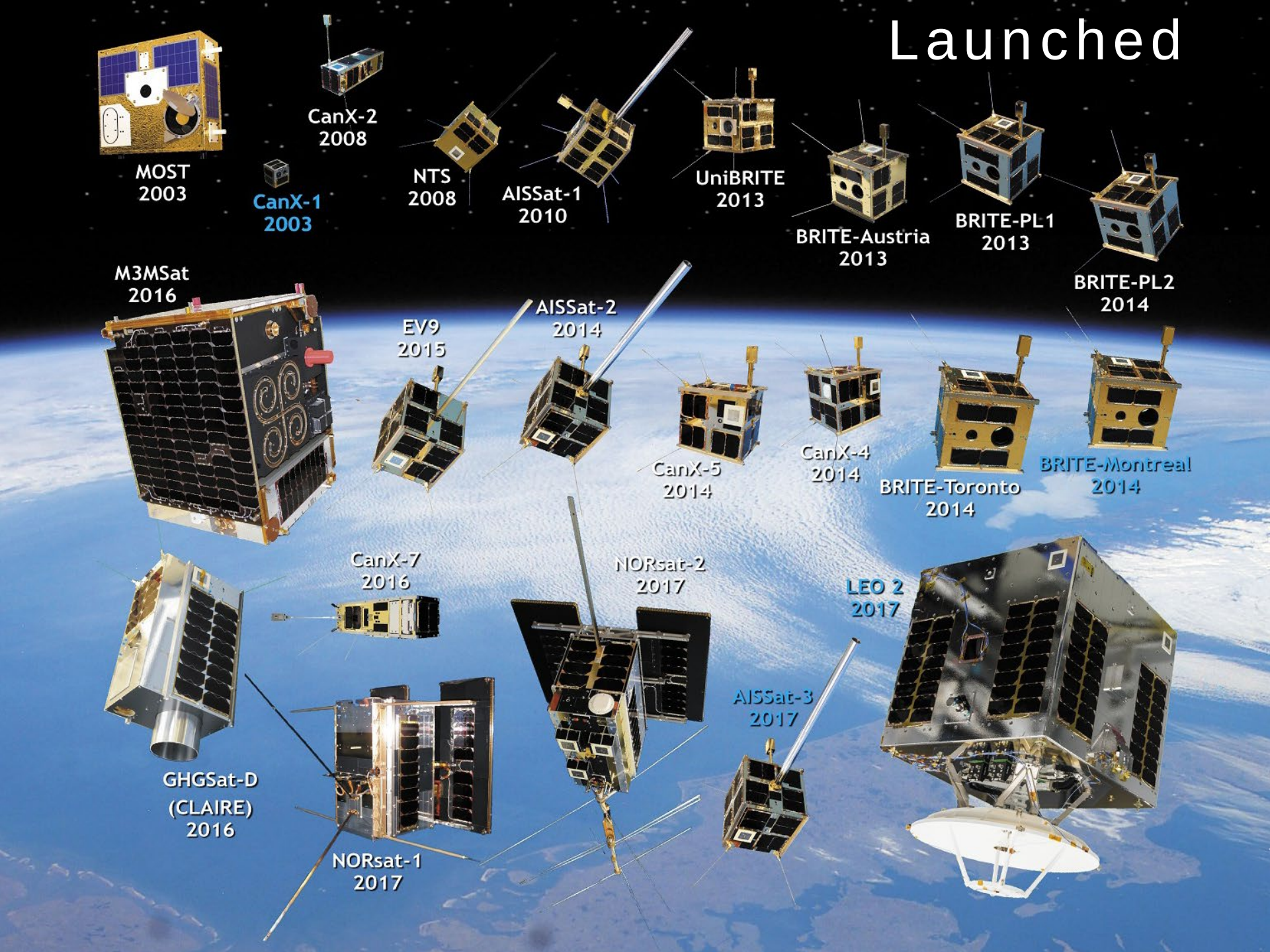


BRITE-CA, CanX-4&5, AISSat-2, EV9 in SFL Clean Room

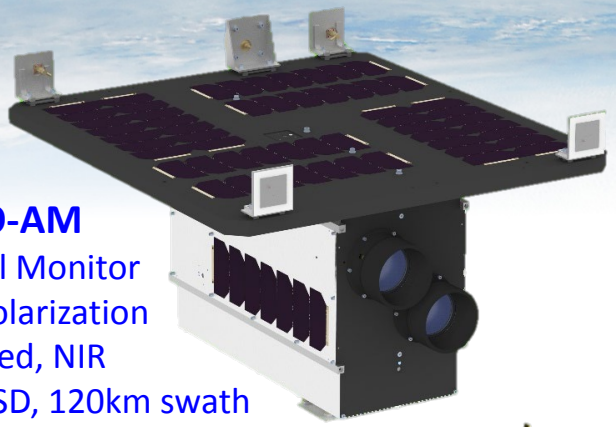
LEO 2 under Vibration Testing at SFL

- **Worldwide.** Developing high performance low-cost missions for end users worldwide.
- **Experience.** In 20 yrs, 18 operational satellites, 11 more satellites to be launched soon. 85+ yrs cumulative heritage. Trained ~100 graduate students.
- **Professional grade**. SFL is a Not-for-Profit self-sustaining specialty lab. 37+ full-time professional staff engineers, 15 graduate students active in program.
- **Pushing the envelope**. SFL challenges the state of the art with lower cost satellite solutions for existing applications currently owned by larger satellites.
- **Leadership.** Among the most advanced nanosatellites and small microsatellites in the world. Missions (3-500kg) at fraction of typical price relative to performance.
- **Lower entry barriers**, more satellites. Leveraging SFL yields highest value per dollar. SFL's cost advantage is its unique approach.

Launched

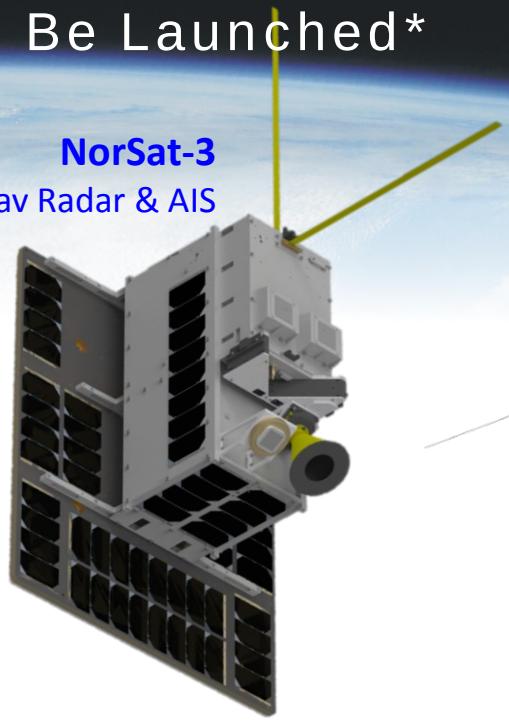

MOST
2003
CanX-2
2008
CanX-1
2003
NTS
2008
AISSat-1
2010
UniBRITE
2013
BRITE-Austria
2013
BRITE-PL1
2013
BRITE-PL2
2014
M3MSat
2016
EV9
2015
AISSat-2
2014
CanX-5
2014
CanX-4
2014
BRITE-Toronto
2014
BRITE-Montreal
2014
CanX-7
2016
NORsat-2
2017
LEO 2
2017
AISSat-3
2017
GHGSat-D
(CLAIRE)
2016
NORsat-1
2017

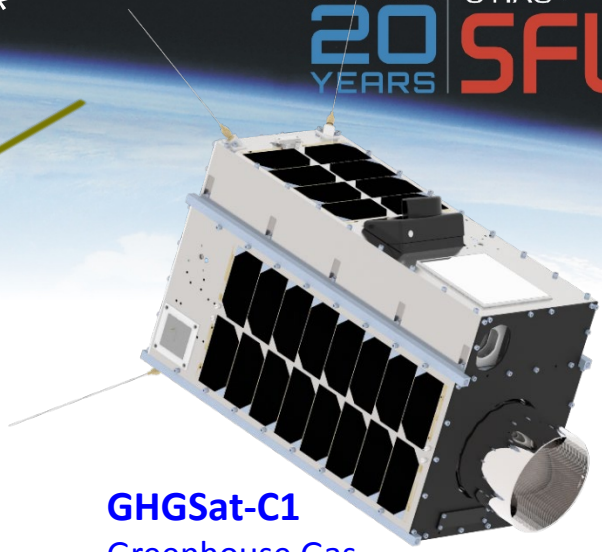
To Be Launched*



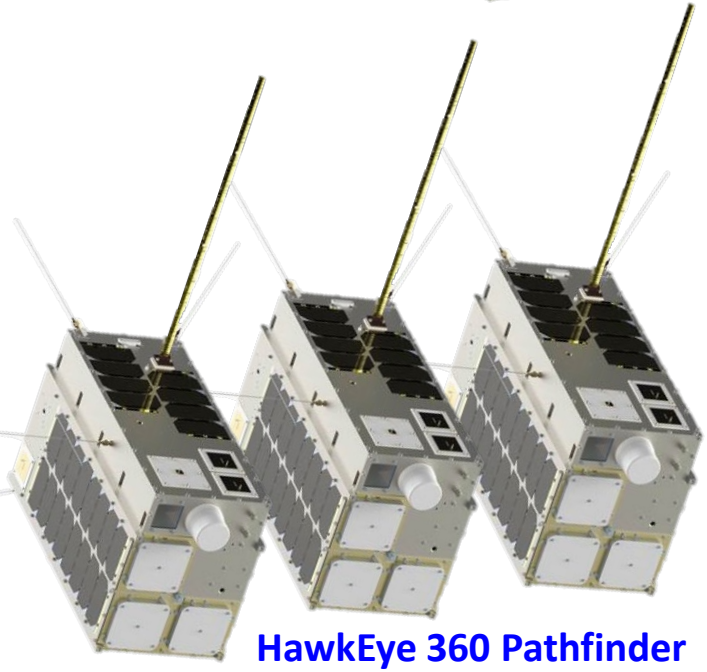
NEMO-AM
Aerosol Monitor
Dual polarization
Blue, Red, NIR
40m GSD, 120km swath

NorSat-3
Nav Radar & AIS

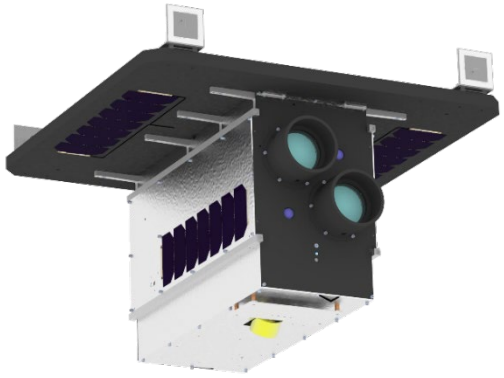




GHGSat-C1
Greenhouse Gas
Monitoring



HawkEye 360 Pathfinder
Geolocated Wideband RF
Mapping and Monitoring



DMSat-1 (AirWatch)
Aerosol and
Greenhouse Gas
Monitor

NEMO-HD
High definition imaging and video
4 bands + pan, 2.8m resolution

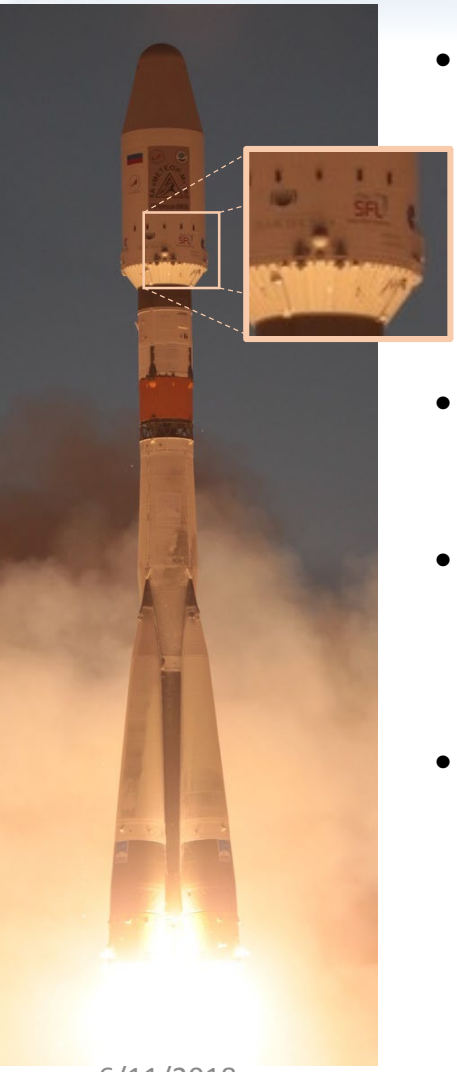
Mission Success Approach

- Don't rely predominantly on a parts standard for mission assurance.
- Convince yourself that the parts used will work in space through test.
- SFL uses commercial components rated over the industrial temperature range, relies on heritage and radiation test program.
- Use heritage parts for critical units, new parts in non-critical areas before promoting them to critical usage.
- Thorough understanding of environment, good design, testing at all levels are essential for small mission success.
- Uncomfortable transition for some – from standards, process, hi-rel parts (distributed reliability approach) to system scrutiny (centralized reliability approach) without "guarantees."
- Small spacecraft have fewer parts and should be inherently more reliable. Simplicity (vs. redundancy) is a key element of small mission reliability.
- Small mission failures will be caused by human error, not strictly parts selection.

Complete Solutions

Service Area	SFL Capability	Examples
Satellite development	Extensive, 20 years	18 operational, 13 ready or in construction, 85+ years cumulative on orbit operation.
Payload integration	Extensive	MOST, CanX-2, NTS, AISSat-1,2&3, BRITE(6), NEMO-AM, NEMO-HD, CanX-7, EV9, NORSAT-1&2, GHGSAT-D
Release mechanisms	XPOD for nanosats	27/27 successful ejections on orbit.
Software (space/ground)	Extensive	Satellites, ground segment, mission planning, orbit acquisition and phasing, formation control
Launch arrangements	32 satellites for 10 countries, 17 clusters	NLS-1 thru NLS-9, NLS-11, NLS-12, NLS-14, NLS-15, NLS-17, NLS-19 through NLS-22. Future: NLS-16, NLS-18, NLS-23 thru NLS-24
Commissioning	At both SFL MCC and client locations	MOST, NTS, CanX-2, CanX-4, CanX-5, AISSat-1, AISSat-2, UniBRITE, BRITE-Austria, BRITE-Toronto, EV9, GHGSat-D, CanX-7, NORsat-1, NORsat-2
Operations Handover	Delivery after commissioning	MOST, AISSat-1,2&3, NEMO-AM, NEMO-HD, BRITE-Austria, BRITE-PL1/2, EV9, NORsat-1, NORsat-2
Operations	At both SFL MCC and remote stations	MOST, NTS, CanX-2, CanX-4, CanX-5, AISSat-1, AISSat-2, UniBRITE, BRITE-Austria, BRITE-Toronto, EV9, GHGSat-D, CanX-7
Ground stations / Mission Control Centers	Worldwide	Svalbard, Andoya, Tromso, Mt. Stromlo, Ottawa, Graz, Vienna, Warsaw, UBC, Panama, Vardo

SFL Launch Program



- SFL Launch Service
  - Ensures rapid, reliable, economical access to space for SFL missions.
  - 32 satellites on Rockot, Cosmos-3M, PSLV, Dnepr, Soyuz-2/Fregat
  - International partners are welcome to join SFL launches.
  - Complete end-to-end service, multiple concurrent launches possible.
- Access to multiple launch vehicles:
  - PSLV, Dnepr, Soyuz-2/Fregat, Soyuz-2, Zenit, Cyclone-4.
- Access to rare and exotic orbits:
  - Dawn-dusk SSO, equatorial, low-altitude, high-altitude, highly elliptical orbit, Molniya, Lagrangian Point L2, Magneto-synchronic, GEO.
- Good, direct working relationships with Space Agencies and Launch Providers.
  - provides flexibility, ability to customize LV hardware.

Conclusion

- SFL lowers the entry barrier to enable others to utilize space for various applications around the world.
- SFL delivers highly capable missions at a fraction of the traditional cost.
- SFL specializes in high performance nanosatellites and next generation microsatellites.
- Amenable to mass production approaches for large constellations.
- Proven capabilities: 85+ years cumulative on-orbit heritage (and growing).
- SFL delivers **bigger** returns from ***smaller*** satellites.

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